

Biofuels for Sustainable Transportation

Ethanol and Fuel Cells The Future is Now!

November 14, 2002 - Honolulu, HI

What is a Fuel Cell?

Fuel cells work by combining hydrogen and oxygen in a chemical reaction to create electricity, without the noise and pollution of conventional engines.

In principle, a fuel cell works like a battery.

Unlike a battery, however, a fuel cell does not run down or require recharging.

It will produce energy in the form of electricity as long as fuel is supplied.

Ethanol $\text{C}_2\text{H}_5\text{OH}$

Why does ethanol have a future as the fuel source for fuel cells?

Ethanol is a hydrogen-rich liquid, which overcomes both the storage and infrastructure challenges of hydrogen for fuel cell applications.

Why Ethanol?

- **Ethanol promotes fuel flexibility/diversity**
 - Coexists with Gasoline, Natural Gas
- **Ethanol will leverage existing investments**
 - Ethanol production/distribution infrastructure
 - Fuel Cell R&D- Government and Commercial
- **3 market areas- with different timing**
 - Stationary power
 - Ethanol-Hydrogen refueling stations
 - Ethanol/Gasoline fuel cell vehicles
- **Ethanol will continue to receive government focus because of it's high societal benefits**
 - Economic, Energy Security, Environmental.

Societal Benefits are High

- **Improved air quality,**
- **Increased energy security,**
- **Economic opportunities for farmers and fuel distributors.**
- **Production from cellulosic biomass feedstocks, such as corn stover, rice straw, and forestry residues.**
- **Spills or leaks will not pollute groundwater**

The Societal Benefits of Ethanol are High

Ethanol and fuel cells together create significant synergy, reaching markets and bringing benefits that are *not* achievable with any other fuel or with any other power technology.

Ethanol is a renewable resource that is playing an increasingly important role in assuring the nation's air quality, improving the economic security of America's farming communities, and addressing the challenges of homeland energy security.

Ethanol & Fuel Cells – The Power of 2”

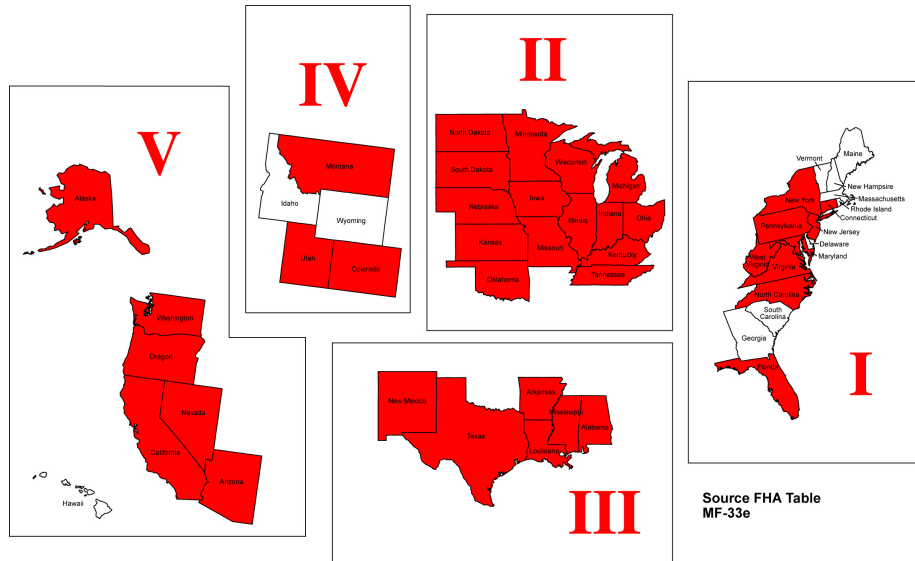
- Ethanol blends seamlessly with gasoline fuels to create an improved, fuel cell fuel that is easily stored and dispensed. These blends can be varied over time, providing fuel source flexibility.
- Ethanol, a renewable fuel, used in fuel cell vehicles or for stationary power plants generates far fewer greenhouse gases than conventional fuels such as gasoline or natural gas.
- Fuel cells are extremely efficient powerplants, reducing the importance of fuel cost and leveling the playing field vs. fossil fuels.
- Ethanol's distribution infrastructure is complete to the terminal level, meaning that only very limited investment in local distribution could enable ethanol to power fuel cells for remote residences and cell towers far from the electric grid.
- Unlike other fuel cell alternative fuels like hydrogen or methanol, ethanol has a very positive environmental, health, and safety footprint with no major uncertainties or hazards.
- The technology to use ethanol in fuel cells already exists and has been demonstrated. Only minor changes are required to existing systems to introduce ethanol as a fuel cell fuel.

Driving On Ethanol

- **An ethanol fuel cell vehicle (FCV) will emit about 13% of the tailpipe pollutants compared with a gasoline vehicle and less than half the pollutants of even a gasoline hybrid vehicle.**
- **Greenhouse gas emissions from an ethanol FCV would be substantially less than even an advanced vehicle using a gasoline internal combustion engine. The ethanol FCV contributions to greenhouse gases could be close to zero if cellulosic biomass is used for the ethanol feedstock.**
- **Unlike hydrogen and methanol, ethanol poses no unique or potentially “show-stopping” health and safety hazards.**
- **Unlike other fuel cell alternative fuels like hydrogen or methanol, ethanol has a very positive environmental, health, and safety footprint with no major uncertainties or hazards.**

Source: Based on 2001 California Fuel Cell Partnership Study

Ethanol is Already Widely Available

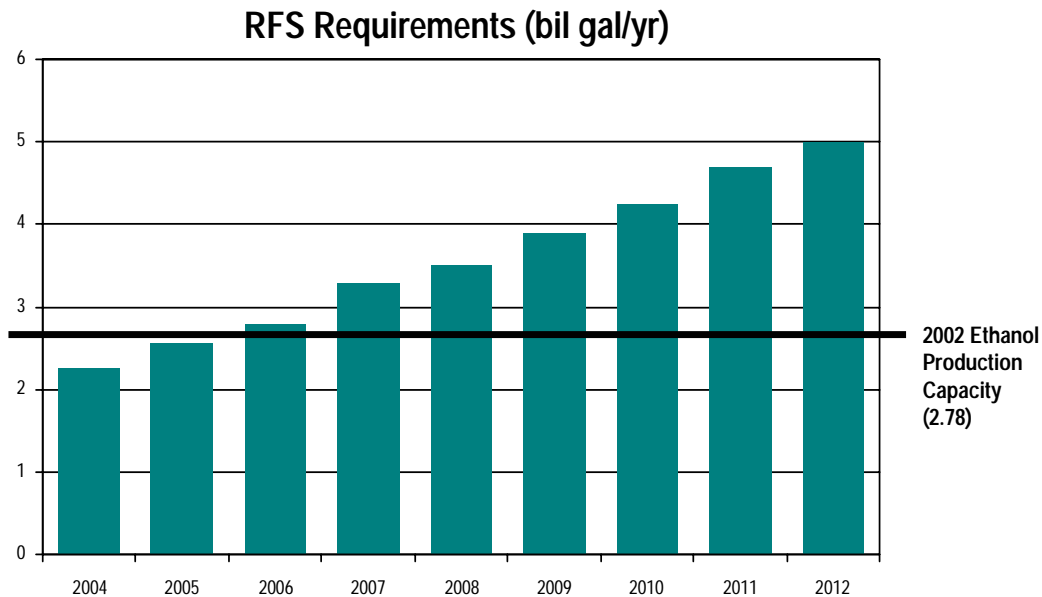


“The outlook for ethanol has never been brighter. Demand for clean-burning, domestic, renewable fuels is at an all-time high, and the US ethanol industry is rising to the challenge.”

Bob Dinneen
President & CEO
Renewable Fuels Association

The ethanol infrastructure is second only to gasoline as a passenger car fuel.

Ethanol Use Will Grow



Source: Downstream Alternatives, Inc.

The Renewable Fuels Standard (RFS) would gradually increase the use of renewable fuels such as ethanol by 0.3 to 0.4 billion gallons per year (bgy), reaching 5.0 bgy by 2012. This increase in demand will require a substantial investment in new ethanol production facilities – an investment that largely will be made in the nation's rural communities.

Benefits of an RFS

An RFS that grows to 5 billion gallons of ethanol by 2012 would have a significant impact on both the farm and overall economy over the next decade:

- Reduce crude oil imports by 1.6 billion barrels.
- Reduce the US trade deficit by \$34 billion.
- Create 214,000 new American jobs.
- Increase US household income by \$51.7 billion.
- Create \$5.3 billion in new investment in renewable fuel production facilities.
- Increase demand for grain (mainly corn) an average of 1.4 billion bushels and soybeans 144 million bushels.

Source: AUS Consultants, Inc.

California Fuel Cell Partnership Conclusions about Ethanol

The fuels assessment study released by the Partnership in October 2001 presented the following conclusions about ethanol as a fuel for fuel cell vehicles:

- A "***major advantage***" of ethanol is its compatibility with gasoline reformer technology and its flexibility to be used neat (i.e., only ethanol) or in a range of gasoline/ethanol blends.
- Flexibility, combined with ethanol's compatibility with the gasoline infrastructure, means that ethanol can be optimized regionally and according to ethanol economics and availability vs. gasoline. This is the only proposed fuel cell vehicle fueling strategy that does not require the commitment of major infrastructure investments to a single fuel.
- An ethanol reformer could be simpler, more reliable, and less costly than a gasoline/multifuel reformer, increasing ethanol's attractiveness as a neat fuel for fuel cell vehicles

3 Market Areas

Hydrogen Fueling Stations- Ethanol converted to hydrogen at a service station site. Would support early vehicle demonstrations.

Stationary Power- Ethanol can be used to make power locally. Cost competitiveness depends on:

- FC cost & efficiency improvements
- Ethanol pricing vs. propane and natural gas
- State/federal incentives for renewables

Fuel Cell Vehicle Fuel- Ethanol (or blend) used in "gasoline" fuel cell vehicles.

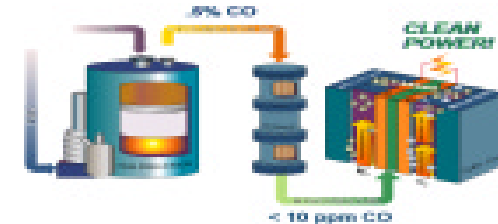
Stationary Power Demonstration



Program Partnership

NUVERA

- PEM Fuel Cell and Reformer
- Fuel Cell Control
- System Testing and Key System Variables Data Acquisition
 - ♦ Fuel Processor, Fuel Cell, Byproduct Management
 - ♦ Fuel Cell Control, System Control Interface



CATERPILLAR

- Program Management
- System Control
- System Testing and Data Acquisition
 - ♦ Inverter, Supporting Electronics
 - ♦ Electrical Power System Components



WILLIAMS BIO-ENERGY

- Ethanol Fuel Source
- System Test Facility
- System Test Monitoring
 - ♦ Installation & Integration
 - ♦ Facility Monitoring



Homeland Security & Energy Independence

“America cannot have homeland security without energy independence.”

President George W. Bush

“73 percent of Americans believe the US should develop new energy sources to diminish its dependence on Mideast oil supplies.”

**Newsweek Poll,
November 2001**

Ethanol Around The World

Brazil-Volkswagen plans to produce 100,000 ethanol-fueled cars in Brazil, exchanging the finance for Kyoto carbon credits with the Brazilian government.

India- August 14 2002 The Indian government ordered the compulsory sale of ethanol-blended gasoline from January 2003 in 13 of the country's states and territories.

China- In November 2001 started to construct its first ethanol plant in Jilin province.

France- bio-ethanol is “a boon to... Agriculture! Bio-Fuels produce some unsuspecting benefits for the environment. Notably in agriculture where once fallow fields are again in use, and jobs are created in rural areas. Even better, increased plant growth reduces CO₂ in the air, as the growing plants "trap" it by photosynthesis.”
-Oxygen, Peugeot Citroen Magazine

Near Term Actions Awareness and Engagement

1. Raise stakeholder awareness
 - Economic analyses to define competitive markets
 - Ethanol supply, and infrastructure development status
 - Conference presentations
2. Identify Fuel Cell companies willing to include ethanol in market development.
3. Evaluate technical and economic feasibility of building an ethanol-hydrogen fueling station.
4. Engage the automotive industry to gain further acceptance of ethanol
5. Work with the DOE to tailor existing technology programs to the use of ethanol.
6. Work with state and local governments to define ethanol role in renewable power programs.

The RFA Fuel Cell Task Force

Mission

The Renewable Fuels Association's Fuel Cell Task Force, seeks to promote the advantages of renewable ethanol as a fuel source for fuel cells, which offer significant promise in reducing fossil fuel use and increasing energy efficiency. In doing so, we also seek to advance ethanol fuel cells in all practical applications including mobile and stationary power.

The RFA is an active member of the U.S. Fuel Cell Council.

Fuel Cell Task Force Members

- Jeff Oestmann, Cargill Inc.
- Randall Doyal, Al-Corn Clean Fuel
- Charles Corr, Archer Daniels Midland
- Jacki Fee, Cargill Inc.
- Robert Reynolds, Downstream Alternatives Inc.
- Glenn Kenreck, GE Betz
- Jeff Roskam, ICM, Inc.
- Philip Shane, Illinois Corn Growers Association
- David Loos, Illinois Department of Commerce and Community Affairs
- Neil Koehler, Kinergy, LLC
- Duane Adams, Minnesota Corn Growers Association
- Jon Doggett, National Corn Growers Association
- Todd Allsop, New Energy Corp.
- Gary Welch, Williams Bio-Energy
- Mary Giglio, Renewable Fuels Association